Claims

1. A mass spectrometer comprising:

an ion source (1) for emitting a beam of ions (2);

collimating and/or focusing means (3) downstream of said ion source (1) for collimating and/or focusing said beam of ions (2) in a first (y) direction;

a lens (4) downstream of said collimating and/or focusing means (3) for deflecting and/or focusing said beam of ions (2) in a second (z) direction perpendicular to said first (y) direction;

a mass analyser (9) downstream of said lens (4), said mass analyser (9) having an entrance region (10) for receiving ions, said ions being subsequently transmitted through said mass analyser (9), said mass analyser (9) further comprising a detector (13);

characterised in that:

said lens (4) is arranged and adapted to be operated in at least a first relatively higher sensitivity mode and to automatically switch to a second relatively lower sensitivity mode, wherein in said second mode ions are defocused by said lens (4) so that substantially fewer ions are received in said entrance region (10) of said mass analyser (9) than in said first mode.

2. A mass spectrometer as claim in claim 1, wherein said ion source (1) is a continuous ion source.

3. A mass spectrometer as claimed in claim 2, wherein said ion source (1) is selected from the group comprising: (i) an electron impact ("EI") ion source; (ii) a chemical ionisation ("CI") ion source; and (iii) a field ionisation ("FI") ion source.

4. A mass spectrometer as claimed in claim 3, wherein said ion source (1) is coupled to a gas chromatograph.

5. A mass spectrometer as claimed in claim 2, wherein said ion source (1) is selected from the group comprising: (i) an electrospray ion source; and (ii) an atmospheric pressure chemical ionisation ("APCI") source.

6. A mass spectrometer as claimed in claim 5, wherein said ion source (1) is coupled to a liquid chromatograph.

7. A mass spectrometer as claimed in claim 1, wherein said mass analyser (9) comprises a time to digital converter.

8. A mass spectrometer as claimed in claim 1, wherein said mass analyser (9) is selected from the group comprising: (i) a quadrupole mass analyser; (ii) a magnetic sector mass analyser; (iii) an ion trap mass analyser; and (iv) a time of flight mass analyser, preferably an orthogonal acceleration time of flight mass analyser.

9. A mass spectrometer as claimed in claim 1, further comprising control means arranged to alternately or otherwise regularly switch said lens (5) back and forth between said first and second modes.

10. A mass spectrometer as claimed in claim 9, wherein said mass spectrometer spends substantially the same amount of time in said first mode as in said second mode.

11. A mass spectrometer as claimed in claim 9, wherein said mass spectrometer spends substantially more time in said first mode than in said second mode.

12. A mass spectrometer as claimed in claim 1, further comprising control means arranged to switch said lens (4) from said first mode to said second mode when said detector (13) is approaching or at the limit of its sensitivity and/or to switch said lens (4) from said second mode to said first mode when a higher sensitivity is possible without said detector (13) substantially saturating.

13. A mass spectrometer as claimed in claim 12, wherein said control means decides whether or not to switch said lens (4) between first and second modes and vice versa by considering whether or not predefined mass peaks or mass peaks within one or more predefined mass ranges are approaching saturation or are substantially saturated.

14. A mass spectrometer as claimed in claim 13, wherein said predefined mass range(s) includes a range having a mass to charge ratio ("m/z") selected from the group comprising: (i) $m/z \geq 40$; (ii) $m/z \geq 50$; (iii) $m/z \geq 60$; (iv) $m/z \geq 70$; (v) $m/z \geq 80$; (vi) $m/z \geq 90$; (vii) $m/z \geq 100$; and (viii) $m/z \geq 110$.

15. A mass spectrometer as claimed in claim 1, further comprising a power supply capable of supplying from -100 to +100V dc to said lens (4).

16. A mass spectrometer as claimed in claim 1, wherein said lens (4) is an Einzel lens comprising a front, intermediate and rear electrode, with said front and rear electrodes being maintained, in use, at substantially the same dc voltage and said intermediate electrode being maintained at a different voltage to said front and rear electrodes.

17. A mass spectrometer as claimed in claim 16, wherein said front and rear electrodes are arranged to be maintained at between -30 to -50V dc for positive ions, and said intermediate electrode is switchable from a voltage in said first mode of $\leq$ -80V dc, preferably approximately -100V dc, to a voltage $\geq$ +0V dc, preferably approximately +100 V dc.

18. A mass spectrometer comprising:

an electron impact ("EI") or chemical ionisation ("CI") ion source (1);

one or more y-focusing lenses (3) downstream of said ion source (1);

a z-lens (4) downstream of said ion source (1);

a mass analyser (9) downstream of the at least one y-focusing lens (3) and said z-lens (4), said mass analyser (9) comprising a time to digital converter;

characterised in that:

said mass spectrometer further comprises control means for automatically controlling said z-lens (4), wherein said control means is arranged to selectively automatically defocus a beam of ions (2) passing through the z-lens (4).

19. A mass spectrometer as claimed in claim 18, wherein when said z-lens (4) defocuses a beam of ions (2) passing through the z-lens (4), the beam of ions (2) is diverged to have a profile which substantially exceeds an entrance aperture (10) to said mass analyser (9).

20. A mass spectrometer comprising:

a continuous ion source (1);

a mass analyser (9) having an entrance aperture (10);

a z-lens (5) disposed between said ion source (1) and said mass analyser (9);

characterised in that:

said z-lens (5) is arranged and adapted to be operated in: (i) a first mode so as to focus a beam of ions (2) passing therethrough so that at least 80% of said ions will substantially pass through said entrance aperture (10); and (ii) a second mode so as to defocus a beam of ions (2) passing therethrough so that 20% or less of said ions will substantially pass through said entrance aperture (10).

21. A mass spectrometer as claimed in claim 20, wherein in said first mode at least 85%, 90%, 95%, 96%, 97%, 98%, 99% or substantially 100% of said ions are arranged to pass through said entrance aperture (10).

22. A mass spectrometer as claimed in claim 20 or 21, wherein in said second mode less than or equal to 15%, 10%, 5%, 4%, 3%, 2%, or 1% of said ions are arranged to pass through said entrance aperture (10).

23. A mass spectrometer as claimed in claim 20, wherein the difference in sensitivity between said first mode and second mode is at least x10, x20, x30, x40, x50, x60, x70, x80, x90 or x100.

24. A mass spectrometer comprising:

an ion source (1);

a lens (4) downstream of said ion source (1);

a detector (13) downstream of said lens (4);

characterised in that:

said lens (4) focuses a beam of ions in a first mode of operation and substantially defocuses a beam of ions in a second mode of operation, wherein a control means is arranged to automatically switch said lens (4) between said first and second modes of operation.

25. A method of mass spectrometry comprising:

providing an ion source (1) for emitting a beam of ions (2);

providing collimating and/or focusing means (3) downstream of said ion source (1) for collimating and/or focusing said beam of ions (2) in a first (y) direction;

providing a lens (4) downstream of said collimating and/or focusing means (3) for deflecting or focusing said beam of ions (2) in a second (z) direction perpendicular to said first direction (y);

providing a mass analyser (9) downstream of said lens (4), said mass analyser (9) having an entrance region (10) for receiving ions, said ions being subsequently transmitted through said mass analyser (9), said mass analyser further comprising a detector (13);

characterised in that said method further comprises the step of:

arranging and adapting said lens (4) so as to be operable in at least a first relatively higher sensitivity mode and to automatically switch to a second relatively lower sensitivity mode, wherein in said second mode ions are defocused by said lens (5) so that substantially fewer ions are received in said entrance region (10) of said mass analyser (9) than in said first mode.

26. A mass spectrometer comprising:

an ion source (1) for emitting a beam of ions (2) along an x-axis;

a z-lens (4) for deflecting and/or (de)focusing said beam of ions;

a mass analyser (9) having an entrance acceptance profile;

characterised in that:

said z-lens (4) is arranged to automatically switch between two modes: (i) a higher sensitivity mode wherein said z-lens (4) focuses said beam of ions (2) so that >60%, preferably >75%, of said ions fall within the entrance acceptance profile of said mass analyser (9); and (ii) a lower sensitivity mode wherein said z-lens (4) defocuses said beam of ions (2) so that <40%, preferably <25%, of said ions fall within the entrance acceptance profile of said mass analyser (9).

27. A mass spectrometer, comprising:

an ion source (1) for emitting a beam of ions (2);

an ion optical system (3,4) downstream of said ion source (1) for focusing a beam of ions (2) passing therethrough;

a mass analyser (9) downstream of said ion optical system (3,4);

characterised in that:

said ion optical system (3,4) is arranged to automatically switch between at least a first relatively higher sensitivity mode and at least a second relatively lower sensitivity mode, wherein in said second mode ions are defocused by said ion optical system (3,4) so that fewer ions are transmitted to said mass analyser (9) than in said first mode.

28. A mass spectrometer as claimed in claim 27, wherein said ion optical system (3,4) is arranged to automatically switch between three or more different sensitivity modes.

29. A mass spectrometer as claimed in claim 27, wherein the ion optical system (3,4) is arranged to spend approximately the same amount of time in said first mode as it spends in said second mode.

30. A mass spectrometer as claimed in claim 27, wherein the ion optical system (3,4) is arranged to spend substantially more time in said first relatively higher sensitivity mode than in said second relatively lower sensitivity mode.

31. A mass spectrometer comprising:

an ion source (1) for emitting a beam of ions substantially along an x-axis;

ion optical means (3,4) for focusing and defocusing said beam of ions in a y-direction perpendicular to said x-axis and/or in a z-direction perpendicular to said y-direction and said x-axis;

a mass analyser (9) downstream of said ion optical means (3,4), said mass analyser (9) comprising a detector (13);

characterised in that:

said mass spectrometer further comprises automatic control means for automatically switching said ion optical means either:

(i) repetitively and regularly between a first higher sensitivity mode wherein said ion optical means (3,4) focuses an ion beam (2) passing therethrough and a second lower sensitivity mode wherein said ion optical means (3,4) defocuses an ion beam (2) passing therethrough; or

(ii) from a higher sensitivity mode wherein said ion optical means (3,4) focuses an ion beam (2) passing therethrough to a lower sensitivity mode wherein said ion optical means (3,4) defocuses an ion beam (2) passing therethrough, said switching between sensitivity modes being made upon determining that particular mass peaks in a mass spectrum or equivalent thereof are saturating or approaching saturation and/or mass peaks within a particular mass range in a mass spectrum or equivalent thereof are saturating or approaching saturation.

32. A mass spectrometer comprising:

an ion source (1) for emitting a beam of ions substantially along an x-axis;

ion optical means (3,4) for focusing and defocusing said beam of ions in a y-direction perpendicular to said x-axis and/or in a z-direction perpendicular to said y-direction and said x-axis;

a mass analyser (9) downstream of said ion optical means (3,4), said mass analyser comprising a detector (13);

characterised in that:

said mass spectrometer is arranged to automatically adjust said ion optical means (3,4) so that either: (i) data at a relatively high sensitivity and at a relatively

low sensitivity are obtained at substantially the same time; or (ii) only data at a first sensitivity is obtained until it is automatically determined that data at an improved second sensitivity may be obtained, at which point data at said second sensitivity is then obtained.

33. A mass spectrometer as claimed in claim 32, wherein said mass analyser (9) comprises a time of flight mass analyser.

34. A mass spectrometer comprising:

ion optical means (3,4) for selectively focusing/defocusing a beam of ions (2) passing therethrough, said ion optical means (3,4) being positioned upstream of a mass analyser (9); and

automatic control means for automatically varying said ion optical means (3,4) thereby altering the focusing/defocusing of a beam of ions (2) passing therethrough so as to alter the intensity of ions subsequently entering said mass analyser (9).